

Requirements and characteristics of potato varieties in the Kenyan potato processing agricultural sub-sector

Walingo A.M., Lung'aho C. and Kabira J.N.
Kenya Agricultural Research Institute. National Potato Research Centre – Tigoni,
P.O. Box 338, Limuru, Kenya

Abstract. Crop utilization is an important facet of potato production. Processing potatoes adds value and diversify ways in which they are consumed. In Kenya, the increasing demand for processing potatoes has been spurred among other things by increased tourism, urbanization and changing food habits as well as increased wealth culminating into an expanding processing subsector whose integration in the food production chain is crucial for Kenya's agro-industrial development and long term food security. The objective of the study was to determine the potato quality requirements by processors, and to assess potato processing potential of several varieties and clones obtained from various sites in the country. An informal survey of the potato processing industry in Nairobi was conducted, followed by quality evaluation of potatoes grown in different sites in the country. The potato tubers were evaluated for dry matter content, then processed into chips and crisps and subjected to sensory evaluation using an untrained sensory panel. The commonest potato products on the market were found to be chips (French fries) and crisps. Two varieties, namely, Nyayo and Roslin Tana were commercially most often used in processing into chips while Kerr's Pink and Dutch Robjin were commonly used for crisp production. Newer varieties like Tigoni and Asante were slowly gaining roots in commercial production, as the National Potato Research Centre, Tigoni, develops other varieties. Varieties with high dry matter content were found to be more acceptable when prepared

into chips and crisps, than those with low dry matter content.

Introduction

Potato is an important food and cash crop in Kenya and plays a major role in national food security. The crop contributes in alleviation of poverty and income generation by providing employment opportunities in production, processing and marketing sectors, thereby contributing to the national food security goals. Potato production is undertaken to generate cash for small-scale farmers in major potato growing zones, with the main potato crop being harvested in just one month in two seasons per year. The total potato production is 670,300 tonnes annually (Ng'ang'a *et al.*, 2002) on 93,000 ha (FAOSTAT, 2002). Production is set to expand as it extends to the traditional maize growing zones, with increased production likely to spur increased processing. Marketing of consumption potatoes in Kenya is undeveloped with most potatoes being sold in the fresh form (Guyton, 1994). Processing as an extension of storage life or a mechanism for improving the value of otherwise low quality potatoes (Booth and Shaw, 1981) is on the increase due to a growing processing market and high yield potential.

The most important products in the Kenyan potato processing industry are fresh potato chips (French fries), followed by potato crisps and frozen chips. There has been an explosive growth of fast food restaurants and snack bars selling chips in the urban areas

(Walingo *et al.*, 1998). The processing of potato crisps is also rapidly expanding due to changing life styles and eating habits of urbanized Kenyans. The demand for fried potato chips and crisps is also increasing in Kenya as evidenced by new entries in the processing market. Several large companies are also processing frozen potato chips for sale in leading supermarkets for product diversification. The processing industry requires potatoes with well-defined characteristics including high consumer and processing qualities. Consequently, potatoes destined for processing must meet certain quality requirements to be suitable. Varieties currently in commercial production were developed without considering the processors' demands; hence, the need to look into the quality characteristics of common varieties and clones for their suitability for processing. There are therefore many gaps in the potato processing subsector that needs to be documented as a guideline to processors, producers and researchers for development and production of the desired varieties.

The objective of this paper was to characterize the potato processing market in terms of varieties used, available products and their quality, and to evaluate potato processing qualities of several varieties and advanced clones in order to determine their processing potential and recommend them for specific processed products.

Materials and Methods

Survey of potato processing industry. A formal survey of the potato processing industry was carried out in Nairobi with the aim of characterizing the potato processing market using a questionnaire. The questionnaire focused on varieties used for specific products and problems encountered by processors. Visits were made to randomly selected snackbars and restaurants for chips. A visit to major supermarkets to capture available potato products was also done. Two

major supermarket chains and 10 other small supermarkets across the city were visited. A list of crisps processors was compiled from potato products offered in the supermarkets and formal visits made to the processors to be interviewed. A total of 65 owners or representatives of chips outlets were interviewed across the city. The visits targeted hotels, restaurants and snack bars. Fifteen crisps processors were visited and interviewed. The data collected were analyzed by SPSS statistics package.

Potato quality evaluation. Potato tubers were grown in Kabete (1750 masl), Tigoni (2100masl), Mount Elgon (2300 masl), and Embu (1460 masl). In Kenya, the potato crop is grown mainly in the highlands between 1400 to 2700 masl with an average rainfall of 1000 mm per annum or greater (Rhoades *et al.*, 2002). Most of these potatoes were grown under recommended cultural practices in the national performance trials, on farm evaluation trials and standard international field trials (SIFT) across the country. There were therefore 13 samples from Kabete (5 varieties and 8 clones); 9 samples of 2 varieties and 7 clones from the Tigoni breeding section; 6 samples of 4 varieties and 3 clones from Embu and 4 varieties from Meru. Potato crisps, potato chips and boiled potatoes were prepared from these clones, which were then subjected to sensory evaluations by an untrained panel.

Dry matter content determination. Determination of the dry matter content of raw potatoes was by oven drying at 90°C a 30 g sample of sliced samples from three representative potatoes to constant weight in triplicates.

Processing characteristics: Potato chips (French fries). Representative tubers were washed; hand peeled, chipped manually to sizes of 1mm squares and washed to remove surface starch, then superficially dried using hand towels before frying at 180°C until done.

Potato crisps. Thirty (30) representative tuber samples were used for determination of crisp quality. Potatoes were hand peeled, and a hand operated rotary slicer was used to cut the tubers into 1.3mm slices. The slices were washed in cold tap water to remove surface starch, and dried on a clean hand towel, then put in a wire mesh basket for frying at 180° C using a frifri machine. Fried samples were prepared according to the method of Lulai and Orr (1979) and evaluated on a color score of 1 (very light) to 5 (very dark) using the PC/SFA (1978) color chart. Other quality parameters like texture, flavor, and overall acceptability were evaluated organoleptically.

Boiled potatoes. Representative tubers were boiled in water for 30 minutes, followed by sensory evaluation.

Organoleptic tests. An in-house consumer panel (or pilot consumer panels) comprising of more than 10 panelists selected from personnel of National Potato Research Centre-Tigoni were used to determine the relative acceptability of the boiled potatoes, chips and crisps, and identify any product defects. A 9-point hedonic scale was applied to evaluate sensory attributes of color, flavor, texture and overall acceptability of the chips and crisps. A score of 1 was considered extremely bad while that of 9 was extremely good. Scores of 5 and above were regarded as acceptable.

Results and Discussion

The crisps processing industry in Nairobi uses about 2% of the total potato production in Kenya. The sector has been growing since its inception about 20 years ago, with most of the growth-taking place in the last 10 years. This sector still has potential for growth, as evidenced by the number of enterprises that have sprung up recently. Over 40 local crisps manufacturers were found to be in the market with imported crisps coming from Europe, Israel and South Africa, among others (Walingo, 2002). Local processors are faced

with the challenge of improving the quality of crisps that they produce to be able to effectively compete with the international ones available in the local market. Crisps manufacturers are very specific on the qualities they want in potatoes. There was a marked preference for the potato variety Dutch Robyjn, followed by Kerr's pink, which have the desired high dry matter content, round shape and cream flesh color. However, these tubers are often harvested prematurely resulting in undesirable dark crisps.

Potato crisps are packaged mainly in low-density polyethylene that may or may not be printed on. Although polythene is a barrier to moisture and oil seepage, it is not so good a barrier to light or air. A few processors were found to be packaging in the more expensive polypropylene material, which is ideal for crisps as it reduces oxidative reactions that cause breakdown of fats. Within this polyethylene package, evidence of too much oil in the product was clearly visible through the clouding of the package. Draining of excess oil from crisps is necessary before packaging otherwise the crisps become soggy. This can cause rancidity resulting in undesirable odors and flavors, thereby making the crisps unpalatable. To add variety to their products, different flavors including ginger, pepper, cheese, barbeque and different shapes of crisps are produced.

The potato chips snack industry consumes more potatoes than does the crisp sector. However, the amount consumed as chips was difficult to quantify in this study since the establishments did not keep accurate figures on production and some were unwilling to divulge the information. Nairobi City Commission (NCC, 2000) estimates that there are over 800 restaurants and other take-away places selling chips in the city alone. This particular avenue for consumption of potatoes is larger than potato crisps. Although several potato varieties are in use for chips, Roslin Tana and Nyayo, which have dominated the market for decades, are slowly being replaced by other varieties like the newly released Tigoni, Asante and Kimande which have

similar characteristics to Tana and Nyayo but are reported (Lung'aho *et al.*, 2003) to be higher yielding. The general liking is for long shaped tubers.

The findings of this study show that processors are very particular about the quality of the potato varieties they use for processing. This is especially true for crisp manufacturers where only two varieties Kerr's pink and Dutch Robijn are used. For chipping, where tuber quality is not as critical as crisps, various other varieties are used. However, Roslin Tana and Nyayo varieties dominate this market.

The major constraint for processors was the low quality of fresh potatoes, attributed to premature harvesting and mixing of different varieties by farmers. Due to need for quick money or lack of knowledge, farmers harvest potatoes prematurely. In addition, farmers are not given a premium price for good quality potato tubers and therefore have no incentive to keep the tubers until full maturity. This ultimately translates itself in the final quality of the product. The farmers also mix varieties, as the only differentiation for them is either white or red skinned tubers. Tuber maturity is an important quality in fresh potatoes. Good quality potatoes starts with the selection of a good variety grown under good cultural conditions, followed by good handling and storage techniques. Other problems cited by processors included high capital investment for modern equipment; constant power failures and water shortages that result in high losses. The operations are batch type with no level of automation of the processing procedures. The equipments used for processing were also very rudimentary. Most of the processors outside the City Centre buy locally fabricated equipment due to the high cost, which are not so good for controlling temperature during processing. This gives bad quality soggy and dark chips. There is no sorting of tubers and green tubers are often found in the chips. The quality of chips varies across the city with better quality being sold in major hotels and restaurants that target higher income groups than those sold

by snack bars. Such chips are of low undesirable quality although they also cost less. Potatoes are also hand peeled, thus there is a limitation on production capacity per day.

The demand for potato products is likely to increase in view of the increasing population of 4% per year, urbanization and changing food habits. Although most potatoes are eaten fresh in Kenya, like any other developing country, there is an unexploited potential in potato processing. Its use in blended products has yet to be exploited. The frozen fry industry is just but making its debut with a few processors in the market. Most frozen fries are sold in up market supermarkets. Several hotels would prefer to purchase frozen fries as opposed to preparing them from fresh potatoes. These products may offer a more convenient product since preparation of French fries from fresh potatoes is time consuming for fast food restaurants.

Quality evaluation. There were significant differences in the percent dry matter content of the various varieties. Most varieties had acceptable high dry matter content that is desirable for processing. The best clones for processing into chips and crisps were Dutch Robijn, 389746.2, 720118 and 386056.7, which had scores of 1 (one) for both chips and crisps (Table 1). The color of a product is an important sensory attribute, as its appeal to customers will influence their choice to buy the product. In most cases of quality evaluation, emphasis is laid on appearance. The low color scores are indicative of low reducing sugars in the potato tubers. High reducing sugars in fresh tuber results in darkened crisps due to reactions between the reducing sugars and amino acids, making them unacceptable by consumers. A high specific gravity or dry matter content is necessary because it indicates how much water must be evaporated from the potato during the dehydration process. It is actually a measure of the dry matter or "solids" in the potato. High specific gravity potatoes make the best French fries and dehydrated potato products.

Table 1: Dry matter content, chips and crisps colour score from potato tubers obtained from CIP, Kabete.

Variety/clone	Percent dry matter content	Crisps colour score	Chips color score
Asante	21.5	2	2
Dutch Robyjn	22.5	1	1
Torridon	25.7	1	2
720150	26.0	3	2
389746.2	22.0	1	1
720118	25.3	1	1
Sterling	17.5	2	1
380389.1	25.9	2	3
Tigoni	25.7	3	2
3860409	26.2	2	3
387205.5	24.7	2	2
386056.7	24.6	1	1
381390.30	22.0	2	2
Lsd (5%)	0.9807	-	-
CV (%)	15.1	-	-

Based on American Potato and Snack food association color cards on a scale of 1 (light) to 5 (dark).

Physiologically mature tubers have high starch and protein levels and low respiration, water content and sugar levels.

In Table 2, sensory evaluation results for the boiled, chipped and crisped potatoes are presented. There were significant differences for different varieties when processed into the different products. For boiled potatoes, 386040.9, 720150, Dutch Robyjn and Tigoni had highest scores of over six for overall acceptability of the product (Table 2). Other sensory attributes like color, texture and flavor were equally high. Besides color, flavor is one of the most important quality factors of crisps and chips (Pangloli *et al.*, 2002). For the chipped potato, best performers were once again Tigoni, 386056.7 and 381390.30, which had overall acceptability scores of over six. Crisps scores for Dutch Robyjn, Asante, 387205.5, 386040.9 and Torridon were the highest.

KP91301.10 and 720097 had highest dry matter contents with only two varieties having less than 20%. These two are not suitable for processing. Surprisingly, clone 384657.24 scored best for crisps and chips (Table3) yet it had a low dry matter content of only 17.9%. 720097 also, scored, highest for crisps while

Tigoni had a best score of 1 for chips. Clones 384657.24, U5, 72097 and Tigoni scored highly for boiled potatoes (Table 4). The same clones were also best performers for crisp while KP90142.7 and KP91301.10 were the best performers when processed into chips. Except for KP90142.7 and 384651.24 of the material sourced from Mt Elgon site, the rest of the clones had over 20% dry matter content (Table 5). Tigoni and 384651.24 scored best for color of crisps. Table 6 further presents results for sensory evaluation of boiled, chipped and crisped potatoes from Mt. Elgon material. There were significant differences between varieties for all sensory attributes of color texture, flavor and overall acceptability for the three different products of boiled, chipped and crisped potatoes. For boiled potatoes, the best performers were Tigoni KP90142.7 and U5 (Table 6). Best performers for crisps included 384651.24, KP92387.5 and Tigoni; while 920097, KP90142.7 and KP923887.5 were best performers for chips.

K. Pink and Nyayo varieties, which are well adapted in the Embu region, had the highest dry matter contents compared to the newer varieties U5 and KP91301.10 (Table 7). However, both the new varieties scored highly

Table 2: Sensory evaluation results of boiled chips and crisps potatoes from Kabete site.

Variety	Boiled scores				Crisps scores				Chips scores			
	Color	Texture	Flavor	Ovr	Color	Texture	Flavor	Ovr	Color	Texture	Flavor	Ovr
	Torridon	6.4	5.7	5.8	5.7	6.4	5.5	5.2	5.8	5.7	5.3	5.9
380389.1	6.2	4.8	5.2	5.3	5.1	5.0	5.3	5.4	6.2	6.3	5.7	5.9
Sterling	4.2	4.1	4.1	4.1	4.9	5.0	4.9	5.3	5.3	4.7	4.6	4.9
381390.30	6.7	4.8	4.8	5.0	6.0	6.0	6.2	6.3	5.4	4.9	5.0	5.3
D. Robynj	5.8	6.6	6.7	6.2	4.3	4.3	4.4	5.2	6.3	6.4	6.3	6.7
Asante	5.3	4.7	4.6	4.4	5.4	5.5	5.7	5.8	6.6	5.7	5.7	6.1
386056.7	4.7	4.7	4.1	4.6	5.5	6.2	6.1	6.0	5.4	5.9	5.9	5.6
720118	4.4	6.6	6.0	5.7	5.5	5.4	5.6	5.9	3.0	4.0	4.4	4.1
3872055	5.0	4.7	5.1	4.7	5.3	4.3	5.3	5.4	7.0	6.7	6.1	6.6
720150	5.3	6.8	6.9	6.6	5.0	4.3	5.1	5.2	4.4	4.4	5.1	5.0
389746.2	5.2	5.1	5.6	5.4	3.5	4.9	4.2	4.6	5.7	5.9	5.9	5.6
Tigoni	6.6	7.2	6.0	6.1	5.9	6.8	6.0	6.5	4.6	4.6	4.9	5.1
386040.9	6.1	6.6	6.8	6.8	4.5	4.3	4.6	4.5	6.3	5.7	6.4	6.4
Lsd (0.05)	1.398	1.538	1.589	1.537	1.292	1.189	1.341	1.348	1.617	1.314	1.353	1.550
CV (%)	26.9	29.2	30	30	26.9	29.6	30	30	27	22.7	22.9	25.8

1 based on a subjective scale of 1-extremely dislike, to 9-extremely like.

Table 3: Dry matter content, chips and crisp color score for potatoes grown in Tigoni.

Variety	Dry matter content	Potato chips color score	Potato crisps color score
KP91301.10	25.1	3	2
KP92387.5	19.9	3	2
382155.2	22.9	2	2
384651.24	17.9	1	1
KP90142.7	16.8	3	2
Asante	22.6	3	3
720097	24.4	2.5	1
U5	20.4	1	3
Tigoni	22.0	1	3
CV (%)	3.0	-	-
Lsd (0.05)	1.08	-	-

cores are based on PC/SFA scale.

Table 4: Sensory evaluation results for boiled, chipped and crisped products from potatoes grown Tigoni.

Variety	Boiled scores				Crisps scores				Chips scores			
	Color	Texture	Flavour	Overall acceptability	Color	Texture	Flavor	Overall	Color	Texture	Flavor	Overall
Asante	5.4	5.4	5.3	5.4	4.0	4.4	4.7	4.1	4.1	4.9	5.7	5.0
KP92381.5	5.0	5.6	5.4	5.4	4.9	4.8	4.9	4.9	6.0	5.4	5.3	5.4
38465124	7.6	6.4	6.0	7.0	6.7	6.0	5.6	6.3	5.6	5.0	5.6	5.0
KP90142.7	4.7	4.1	5.0	5.0	4.9	5.0	5.1	5.1	7.0	6.1	5.9	5.7
720097	6.3	6.3	5.3	6.0	3.4	4.9	5.1	4.3	6.1	4.6	5.3	5.4
U5	4.9	6.6	6.3	6.6	5.7	6.2	6.4	6.3	6.4	5.9	5.9	5.7
KP91301.10	6.1	6.1	5.6	6.3	6.0	6.0	5.7	6.0	4.0	4.4	4.4	4.9
Tigoni	6.9	5.1	4.9	6.3	6.7	6.8	6.6	6.6	3.6	4.7	5.6	5.4
382155.2	5.3	6.0	5.4	5.4	4.9	5.5	5.9	5.9	3.9	3.3	4.0	4.0
CV (%)	22	26.7	24.7	20.0	31	24	25	23	20.4	27.6	27.1	26.7
Lsd (0.05)	1.362	1.647	1.449	1.283	1.748	1.437	1.537	1.406	1.135	1.461	1.543	1.488

for crisp color, outperforming Asante. Based on their consistently good processing quality, coupled with high field performance across the sites, clones KP91301.10, 920097, KP90142.7 and U5 have been officially given pre-release status as new varieties.

Conclusion and Recommendations

The industry continues to search for potato varieties with better processing quality characteristics to replace the old traditional

varieties like K. Pink and Dutch Robyn for crisps; and Tana, and Nyayo for chips. These varieties have become susceptible to diseases like late blight and viruses hampering their production. The new varieties being developed are not only tolerant to potato diseases but also possess acceptable quality characteristics. A processing potato must have a high specific gravity and low sugar content. High specific gravity is necessary because it indicates how much water must be evaporated from the potato during the

Table 5: Dry matter content, color score for chips and crisps prepared from Mt. Elgon materials.

Variety	Dry matter content	Crisps color score
720097	24.3	2
KP90142.7	18.2	4
Tigoni	26.9	1
KP90301.10	24.0	2
U5	23.4	2
KP92387.5	21.2	3
Asante	20.8	2
384651.24	19.0	1
382155.2	24.2	2
CV (%)	3.5	-
Lsd (5%)	1.372	-

Table 6: Sensory evaluation scores for boiled chipped and crisped potatoes from Mt. Elgon material.

Variety	Boiled scores				Crisps scores						
	Color	Texture	Flavor	Overall	Color	Texture	Flavor	Overall	Color	Texture	Flavor
382155.2	5.0	5.4	5.1	5.4	5.9	5.4	5.0	5.3	5.1	4.4	5.8
KP92387.5	4.4	5.0	4.9	5.0	5.9	6.3	6.0	5.7	6.0	5.5	5.8
384657.24	5.0	4.7	4.7	4.4	7.1	5.6	6.0	6.0	3.8	4.4	3.3
KP90142.7	6.1	4.9	5.1	6.0	5.7	5.4	5.1	5.1	5.7	5.6	5.8
U5	6.3	5.6	5.7	5.7	5.6	5.7	5.6	5.9	5.3	5.0	5.3
Asante	5.3	5.3	4.4	5.0	5.1	5.3	5.4	5.4	5.9	5.0	5.9
KP91301.10	4.6	4.7	4.0	4.1	6.3	5.3	5.1	5.9	4.2	4.8	4.0
720097	5.1	4.1	4.1	4.7	4.7	5.6	5.4	5.4	5.3	5.7	6.0
Tigoni	6.4	6.9	6.1	7.0	7.0	5.9	6.4	6.6	2.9	3.3	3.8
CV	20	22	28	21	18	15	21	17	29	31	29
Lsd	1.156	1.207	1.502	1.191	1.156	1.935	1.267	1.021	1.221	1.313	1.478

Table 7: Dry matter content of Embu materials.

Variety	Dry matter content	Crisps color scale	Chips color score
Kerr's Pink	22.8	1	1
Nyayo	22.7	2	2
Tigoni	19.6	2	1
Asante	19.6	3	2
U5	19.0	1	2
KP91301.10	19.8	1	2
CV	2.4%	-	-
Lsd	0.9005	-	-

dehydration process. High specific gravity potatoes make the best French fries and dehydrated potato products. Lower temperatures or shorter frying time will yield a limp product with poor rigidity; longer frying time or high temperature of oil affects the color of the product (Zak and Holt, 1973).

However, the potato processing industry needs further development. The market is slow in responding to demand. Consumers have shown increased demand for both quality and quantity for processed product, necessitating processors to improve on their products. Local products cannot compete on the international market, as the quality is wanting, both in terms of the actual product and in terms of the packaging. Quality is an essential prerequisite for acceptance of a food product. Consumers select a product according to the external characteristics that are assumed to be indicative of the internal qualities. Kader (1985) indicated that quality factors are the appearance (visual), flavor (taste and odour), texture (feel), nutritive value and safety. Unsuitable varieties, batch type operations, excess oil in product, poor packaging contribute to reduced performance by the potato industry. However, the Kenyan potato industry is currently active in trying to satisfy her customers through linkages between the potato programme and the processors.

Acknowledgement

The International Potato Center (CIP) and the Regional Network for Potato and Sweetpotato Improvement Programme in Eastern and Central Africa (PRAPACE) financial support.

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